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DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

MINING, TREATMENT, METHODS, AND COSTS AT THE GIFFORD HILL & CO. SAND AND GRAVEL PLANT AT HOOT SPUR NEAR TEXARKANA, TEX.

BY

J. W. HIGGS

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MINING. TREATMENT, METHODS, AND COSTS AT THE GIFFORD HILL & CO. SAND AND GRAVEL PLANT AT HOOT SPUR NEAR TEXARKANA, TEX.[1]

By J. W. Higgs[2]

INTRODUCTION

This paper, describing the operation of the Gifford Hill & Co. plant at Hoot Spur near Texarkana, is one of a series being prepared for and published by the United States Bureau of Mines on methods and costs of mining and preparing gravel and sand throughout the United States. These papers are designed to disseminate technical information regarding the methods used. The cost tabulations represent local operating expenditures only and not total production costs. Although the publication of total costs might not be advisable in some instances yet a knowledge of operating costs is essential to the technical discussion and study of methods employed. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulation shall ensue.

The plant described combines some features of dredging and some of dry-pit operation, as material is excavated in a dry pit with a drag line, hauled to the plant in standard-gage cars, and then pumped. This operation should be of special interest to operators whose deposits contain a large quantity of clay.

The deposit is in Bowie County, Tex., about 8 miles south of Texarkana and is served by the Texas & Pacific Railway.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of the officials of Gifford Hill & Co.

HISTORY

In this gravel operation, as in the great majority in this section, the railway company was the original operator. As early as 1900, the Texas & Pacific Railway Co. had a ballast operation about 8 miles south of Texarkana. Material was loaded in ballast cars with a standard-gage railway-type steam shovel. The deposit worked was of the upland type and had a negligible amount of overburden.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U.S. Bureau of Mines Information Circular 6910."

[2] Chief engineer, Gifford Hill & Co., Inc.

From the time of the original operation until about 1918 the railway company pit, and similar deposits were worked by various operators. Several attempts, with varying success, were made to remove the clay and make the material suitable for concrete, but during this period practically all material mined was "road gravel" which was used extensively for surfacing secondary county roads where traffic was comparatively light. In its natural state the material contains enough sand and clay to make a road with all the good features of the old "sand-clay" road and with the further advantage that about 40 to 50 percent of the material is gravel between 1/4 inch and 3 inches. The road gravel was loaded with teams, using ramps and traps over wagons and trucks, or with drag lines.

About 1918 the first plant for producing concrete gravel was put in operation. This plant was operated by several successive producers with somewhat uncertain results. Material was hauled to a settling basin or sump, from which it was picked up by a steam-operated hoist, using a clamshell bucket. The material was elevated to the top of the plant and run through a complicated system of trommel screens, picking belts, etc., to cars or trucks. If the finished material was not satisfactory it was dumped back in the sump and rerun. The final product was satisfactory, but the output was small and the cost of production high.

In 1926 the entire holdings of the company then operating were purchased by Gifford Hill & Co., Inc. These holdings included several leases of old railway ballast pits and land in fee or under lease. The existing plant was on the Cotton Belt Railway about 10 miles west of Texarkana.

The Gifford Hill Co. immediately started construction of a second plant on the Texas & Pacific Railway, designed to produce washed ballast and commercial types of gravel and sand. The company also began a systematic program of testing for gravel and acquiring property showing workable material.

In 1929 the deposit near the plant in operation when purchased had been exhausted, and the construction of a new modern-type plant was begun on the Cotton Belt Railway at Sledge, Tex.

This plant was designed along standard lines - material was hauled to the sump and pumped over a 1/4-inch flat screen, then the plus 1/4-inch material was loaded in ballast cars and hauled to the dump hopper. From the dump hopper it passed over a 30-inch belt conveyor to a series of conical screens on which it was separated into five sizes of gravel and three grades of sand. Approximately 300 cubic yards of storage capacity was provided for each size. From the storage bins the material was remixed as sent to a 30-inch conveyor belt and conveyed to a 30-inch trommel screen, with 1/4-inch openings, where it was given a final washing.

This plant operated with minor changes until 1935, when it was abandoned owing to depletion of deposits within hauling distance. Although the product of the plant was satisfactory the investment was large, and depreciation costs were spread over such a limited period as to make the cost of this type of operation almost prohibitive for working the comparatively small deposits of east Texas.

While this plant was in operation the Gifford Hill Co. installed two others in the same territory. Their design is typical of the company's other operations and is the outcome of experience gained from large plants similar to the one at Sledge.

The large output in this territory is used mainly to supply gravel and sand for paving. It has been found that 5 or 6 years is the average life of a gravel plant before the deposit adjoining it is exhausted and the haul to the washer becomes prohibitive. Later operations have therefore been designed primarily to produce paving gravel and are of much lighter construction. The storage bins and all other features not absolutely necessary to produce satisfactory material are eliminated. The plants appear temporary, and to operators from other sections they resemble makeshifts put together by amateurs. However, they are surprisingly efficient, and the bugbear of high depreciation cost has largely been overcome.

The company believes that the gravel business of the future in this section will be handled entirely by smaller-type plants similar to the Hoot plant. If it were not for the great difference in material from different deposits, a portable or semiportable plant could be designed that would reduce depreciation charges still further. However, as long as each deposit represents a separate problem and the most important materials for construction - wooden posts, timbers, etc. - can for the most part, be secured for the cost of labor alone, plants similar to the one described in this paper will be used extensively in this section.

DESCRIPTION OF DEPOSIT

All deposits found in this vicinity appear to be very similar in character, but the gravel and sand may differ surprisingly in adjoining deposits, and sometimes in the same deposits may have sharply-defined dividing lines. The deposits are all stratified, showing coarse gravel and sand layers separated by fine sand and sometimes clay. The segregation was doubtless accomplished partly by the river currents and partly by successive floods.

For the purpose of this discussion, the gravel worked comes under two general classifications - "upland" and "lowland" deposits. Deposits found in the present flood plains of existing rivers are called lowland deposits, while deposits found in the hills above present plains are called upland deposits.

A more specific differentiation between these two types of deposits may be found in a paper by Walter W. Hyde3/. However, in the Texarkana area the quality of the gravel in the two classes of deposits does not differ appreciably.

Generally, the upland deposits are surface deposits with light overburden. An upland or lowland deposit more than 15 feet deep is very unusual.

3/ Hyde, W.W., Mining Treatment Methods and Costs at East Texas Gravel Co.'s Deposits near Bois D'Arc, Tex.: Inf. Circ. 6537, Bureau of Mines, 1931,p.2.

The average depth of workable gravel is about 8 or 10 feet. The area seldom exceeds 25 acres and averages about 15. However, in 1 square mile as many as 20 separate and distinct deposits have been found. The upland deposits are worked much more easily, and the salable material recovered, after burden is removed, sometimes reached 80 percent compared with an average of 40 to 60 percent for lowland deposits. The principal objection to working upland deposits is their small area, requiring frequent movement of equipment. Generally raw material must be worked at a considerable distance from sufficient water for washing, and most deposits contain large quantities of clay.

The prospecting, exploration, and sampling of deposits probably constitute a more important part of the producer's business in this territory than in almost any other part of the country. The "spotted" character of all deposits, their variation, the frequency with which a preponderance of "mud balls" makes an otherwise valuable deposit worthless, the deceptive appearance of a mediocre sample after it has been "pumped", and the small area of the average deposit make it necessary for the producer to employ a highly trained and expensive testing crew. The testing crew cannot discontinue operations after locating a good deposit. The deposits are all so small that testing is an item of overhead that is practically continuous.

In the Texarkana territory, it is not difficult to locate deposits approximately. The general trend of the flood plain of the ancient river that deposited the gravel is fairly well established. Moreover, every property owner within 20 miles of a working gravel operation is positive that practically all the gravel in Texas is concentrated on his land and is continually bringing this information to producers. The owners stand ready to prove it by gravel found in excavating wells and cellars, and by gravel banks on creeks, etc. Practically all these reports are investigated. If surface indications and other available signs justify it the property is tested.

The general method for testing a piece of property is as follows: A row of holes approximately 400 feet apart is drilled across the property. If no gravel is found, holes are bored 18 to 20 feet deep before they are abandoned. When gravel is encountered spacing is reduced to 200 feet or less, or to whatever interval is necessary to determine accurately the limits of the deposit. The first row of holes is paralleled by another row 200 or 400 feet apart, as may be required, and this process is continued until the limits of the gravel are fairly accurately determined. All holes are numbered and marked with stakes. Regardless of whether or not the gravel as located is considered workable, a map is made of all gravel land tested, and the location of all tests holes is accurately plotted. As shown in figure 1, the irregular spacing and the fact that holes are generally put down without regard to property lines or direction give these test maps a haphazard appearance. A full-time employee, who is an engineer, works with the testing crew and does the necessary surveying, mapping, etc., and takes care of the field analyses of the samples. After the limits of the gravel have been located in the field and mapped, the approximate yardage of pit-run gravel is computed. This information and screen tests of the material permit a rough approximation of the character and volume of salable material. For this computation the following formula is used:

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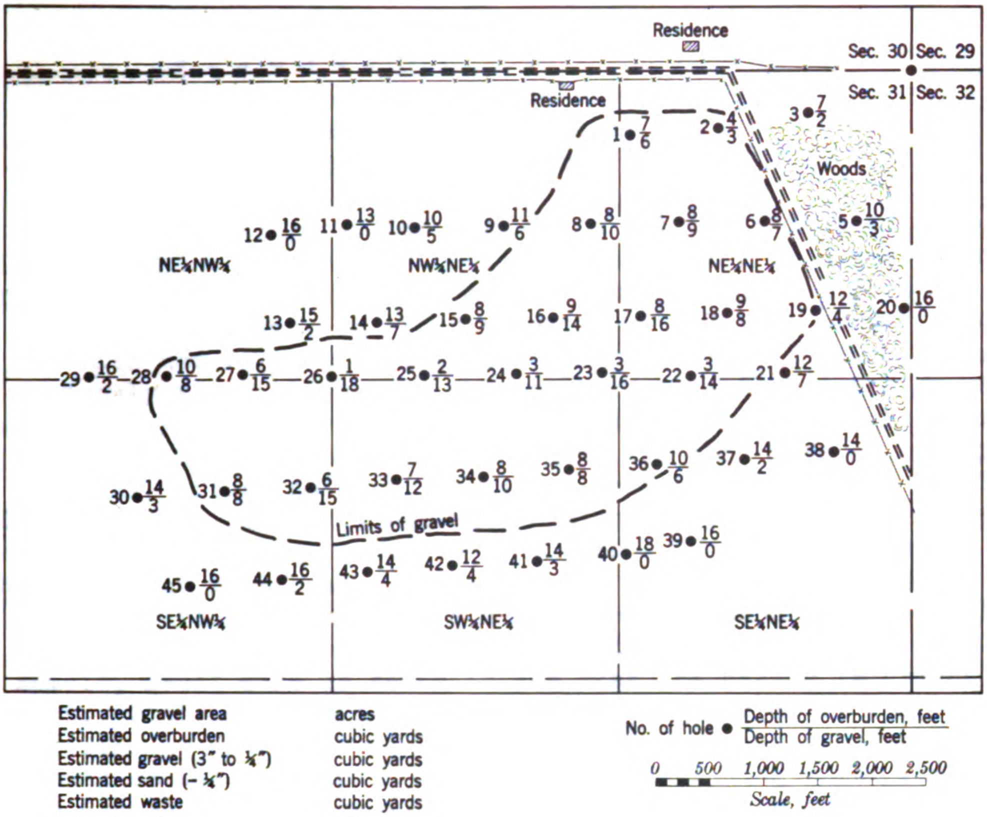

Estimated gravel area acres
Estimated overburden cubic yards
Estimated gravel (3" to ¼") cubic yards
Estimated sand (– ¼") cubic yards
Estimated waste cubic yards

Figure 1.—Drillhole map of typical deposit.

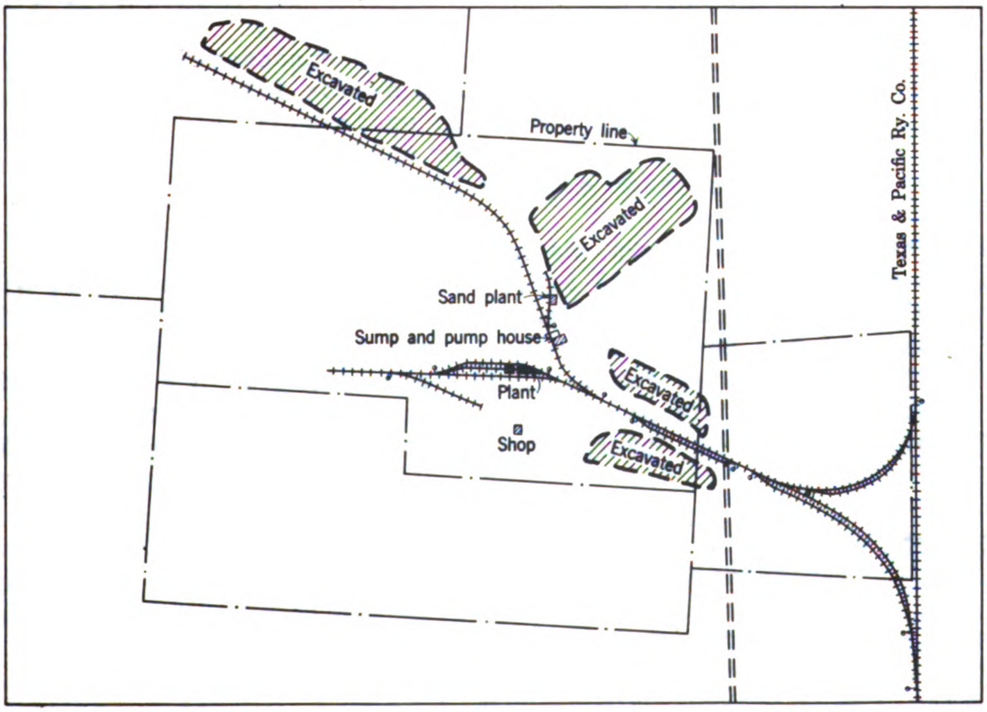

Figure 2.—Map of Hoot property showing tracks, plant, etc.

$S = A \times d \times 1{,}200$

S = salable material, in cubic yards,

A = area of deposit, in acres,

d = average depth, in feet.

A special testing machine mounted on a trailer is used in boring holes. This machine consists of a 22-inch auger driven by a gas engine, and it will bore through ordinary overburden at a rate of 3 to 5 feet per minute. In sand, gravel, loose sand, or other material with little binder frequent cave-ins make its use very difficult if not impossible. In such cases the auger is used only to drill through the overburden, and when the gravel is reached an ordinary flap-valve bailing bucket is used. Two light A frames, built of 2-inch by 6-inch lumber and hinged at the top, form an easily collapsible derrick. After the drill is pulled an 8-inch casing is set in the hole, and the bailing bucket is raised and dropped by one or two men pulling on a 1-inch rope run through a sheave at the top. Usually the impact of the bailing bucket alone will break up the gravel, but in conglomerate or other material that is difficult to break a section of 56-pound rail about 10 feet long and having a sharpened end is used ahead of the bucket. To obtain an accurate sample, great care is taken to see that the casing is driven ahead of the bucket. With an improvised drop hammer weighing about 250 or 300 pounds the casing is driven about 2 feet ahead, or as far as practical at a time, depending on the material. All material, including water removed from the hole, is dumped into a watertight box where the fines are permitted to settle before the water is poured off. The sample is reduced to proper size for further testing by the usual method of quartering. A sample comprises all material taken from each 5-foot drive of the casing.

The following information is obtained from the sample in the field:

1. Percentage of clay and silt.
2. Careful screen analysis.
   a. Percentage of sand minus 1/4 inch.
   b. Percentage of gravel.
   c. Percentage of salable material.

The method used for determining the quantity of silt is as follows: The sample is dried to a constant weight; it is then placed in a pan and covered with water. The mixture is vigorously agitated and the muddy water poured off. This process is continued until the water poured off is clear. The sample is then dried and weighed. The second weight is subtracted from the original weight, and the difference represents the weight of clay and silt. This weight, divided by the original weight and multiplied by 100, gives the percentage of clay and silt.

To determine friable and unsound particles, specific gravity, and absorption other samples are sent to a commercial laboratory.

The cost per day of the testing crew, as outlined above, is about as follows:

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1 foreman (also surveyor or engineer)......		$5.00
1 truck driver and drill operator..........		4.00
3 to 5 laborers...at$3.00..................		12.00
Total cost of labor....................		21.00
Truck (oil, gas, depreciation, etc.)	$4.00	
Drill (oil, gas, depreciation, etc.)	1.50.	5.50
		26.50

The footage of hole drilled and bailed per day varies so greatly than an average can only be obtained by considering an extended period. From August 1934 to August 1935 the cost per foot of hole drilled was $0.52. This amount included total depth of holes drilled with machine and bailer; clearing necessary for moving the rig in timber; and cost of engineering for surveying, plotting, and sampling.

CHOICE OF METHOD

The overburden near the Hoot plant ranges from 1 to 15 feet in depth. The deposit consists of numerous small deposits rather than one large one. (See fig. 2.) Water was encountered at the lower levels in nearly all test holes. For these reasons, a drag line was selected as the best type of machine for digging. The principal digging unit was a walking-type drag line equipped with an 85-foot boom and a 3-cubic yard bucket.

The volume of the deposit to be handled seemed large enough to justify standard-gage railway equipment for hauling. This equipment was therefore installed, using a steam locomotive and 12-yard gravity-dump cars. There is some doubt as to whether or not this method of transportation is the most economical, because the continual moving and laying of new tracks as various pits are exhausted make the costs of pit transportation rather high. When the operation was begun one locomotive hauled raw material to the plant and switched out loaded cars to the main line of the railway, but for the past year the length of haul has so increased that two locomotives are necessary.

Both are 60-ton locomitives, bought from the Texas & Pacific Railway Co. They are oil-burning and have six drivers and a drawbar pull of approximately 20,000 pounds. The maximum length of haul of raw material at Hoot to date has been approximately 1 1/4 miles. For this distance 5-car trains are used. The maximum grade is 2 1/2 percent in favor of the loaded train, and no difficulty is experienced in negotiating this grade with empty cars.

MINING METHODS

Usually at Hoot the same machine that loads the raw material has also done the stripping. However, sometimes it has been necessary to use an additional drag line to remove overburden ahead of the gravel digger. For this purpose, a gasoline drag line with a 50-foot boom and 1 1/4-yard bucket has been used.

The first cut was made as close to the edge of the gravel as possible and the overburden cast away from the track. (See fig. 3.) In successive cuts

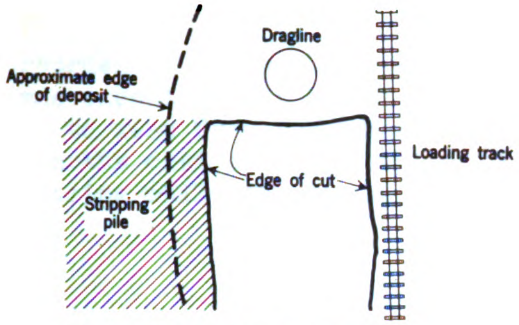
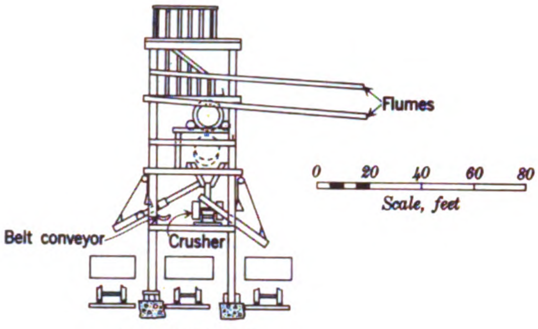
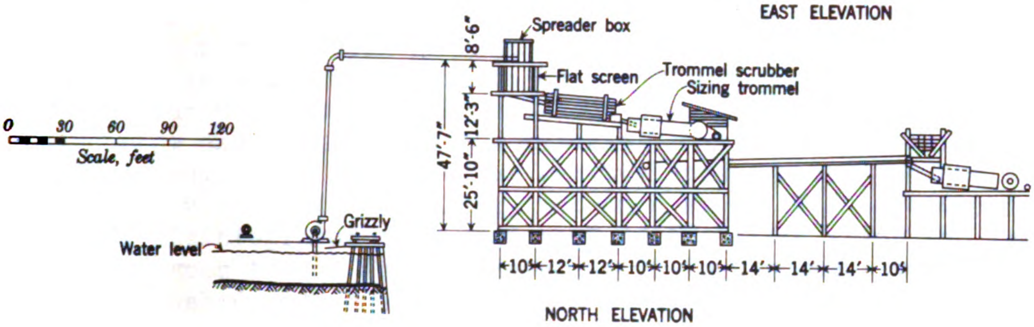


Figure 3.—Plan showing method of making first cut.



EAST ELEVATION



NORTH ELEVATION

Figure 4.—Hoot plant.

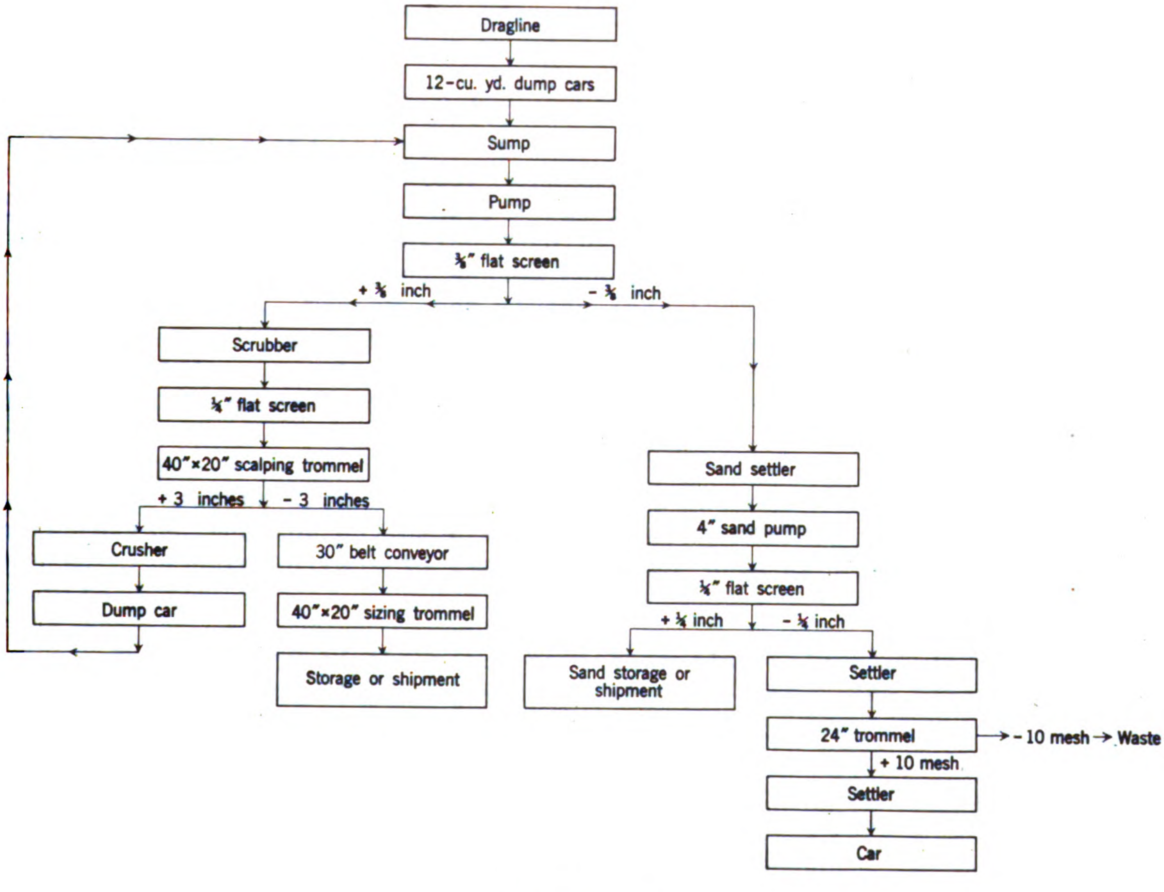


Figure 5.—Flow sheet.

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the overburden is thrown back into the cut previously excavated. Where overburden was exceptionally heavy, it was necessary to haul part of it away in dump cars to keep from covering up too great a percentage of gravel. Accurate figures on the cost of removing overburden are not available separately as the machine strips while the train is hauling raw material to the plant.

SCREENING PLANT

The pit-run material is loaded in 12-yard dump cars and hauled to a sump where it is dumped on a grizzly made of rails spaced about 6 or 8 inches apart. (See fig. 4.) The sump is constructed of timber walls on three sides; a pond on the fourth side supplies the water. The grizzly is about 30 feet long, and the normal depth of water under it is 8 or 10 feet. The material is picked up by an 8-inch pump driven by a 150-horsepower slip-ring motor and elevated about 60 feet through an 8-inch pipe to the top of the plant. From the discharge end of the pipe the material goes to a spreader box 6 feet wide by 10 feet long, then to a flat or gravity screen with 3/8-inch square openings, 6 feet wide by 12 feet long, set on a slope of 8 inches per foot. Here the fines, disintegrated clay, and most of the dirty water are removed. The gravel then goes to a 4 foot-diameter by 20 foot trommel scrubber, where it is further washed with a stream of 600 to 800 gallons per minute of clear water. This scrubber has a slope of 1 1/4-inches per foot and a speed of 18 r.p.m. Virtually all remaining clay balls are completely disintegrated here. After treatment in the scrubber the material is again dewatered over a 1/4-inch flat screen and passed to a 40-inch by 20-foot trommel with 800 gallons per minute of clear water, which completes the washing.

The oversize material (+3 inch) is removed at this trommel and goes through the crusher and into a dump car. When the dump car is filled it is hauled to the sump and rehandled. Crushed material is not returned directly to the screen because occasionally large clay balls get through the scrubber and screen without disintegration, and by returning them to the sump they are eventually broken down and washed away. The material is crushed with a 24 inch jaw crusher. The crusher plates last indefinitely; they are built up when they show wear, and some 300,000 tons have passed through the plant since the present plates were installed. The minus 3-inch material passes to a belt conveyor which carries it to the sizing trommel where marketable sizes are made and dropped to bins.

A complete flow sheet is shown in figure 5. To make sizes other than those required for paving gravel the material going to the crusher may be increased or spouted direct to cars and either sold as ballast or sent to the stock pile.

The capacity of the plant varies considerably with the class of material produced and with the quality of the pit run. The maximum daily output where no material was loaded from the stock pile was 1,070 tons of gravel and 720 tons of sand.

Power is furnished by the Southwestern Gas & Electric Co.

The connected load is as follows:

	Horsepower
Motor on 8-inch gravel pump	1-150
Motor on hoist for raising pump	1-15
Motor on scrubber	1-15
Motor on scalping trommel	1-10
Motor on 4-inch sand pump	1-25
Motor on 30-inch belt conveyor	1-15
Motor on sizing trommel	1-15
Motor on crusher	1-20
Motor on 6-inch Amsco mud pump	1-50
Motor on boiler water	1-10
Motor on arc welder	1-10
Fresh-water pump at sand plant	1-10
Motor on 10-inch clear water pump to washing plant	1-50
Motor on 6-inch pump to rewasher	1-20
	415

The average cost of power is approximately $0.015 per kw.-hr.

Material not sold when produced is stock-piled by a standard-gage railway crane which also reloads this material when sold.

Obtaining fresh water supply for this operation is a problem that has become more and more serious as available space has been filled with waste. At present the problem is solved by a very effective circulating system as shown in figure 6.

A 6-inch sand pump on the bank, with a long suction supported on barrel pontoons, extends into the settling pond. This pump elevates the muddy water about 40 feet to an old pit about 600 feet away. From there the water finds its way back to the pond through gravel filters and reaches it practically free from sediment.

The method of preparing the sand is unusual. All fines below 3/8 inch are removed at the flat screen in the washing plant and flumed to waste. Near the end of the flume a sand settler has been placed. This sand settler is made of wood and is a truncated pyramid, with the large end 2 feet wide and about 6 feet long replacing a section the same size taken from the bottom of the waste flume. A 4-inch pipe has been fitted in the small end or bottom. This is probably the simplest form of sand settler ever used, but in this particular locality it works surprisingly well. A 4-inch sand pump picks up material from the settler and elevates it to a 1/4-inch flat screen similar in construction to the gravel screen but lighter. The -1/4-inch material passes through another settler and into a home-made trommel screen 24 inches in diameter and about 8 feet long. This trommel has a pitch of 1 inch per foot and a speed of 12 r.p.m. The screen openings are approximately 10-mesh. Here the sand is washed with additional clear water, and the washed material goes to a settler and then to the car.

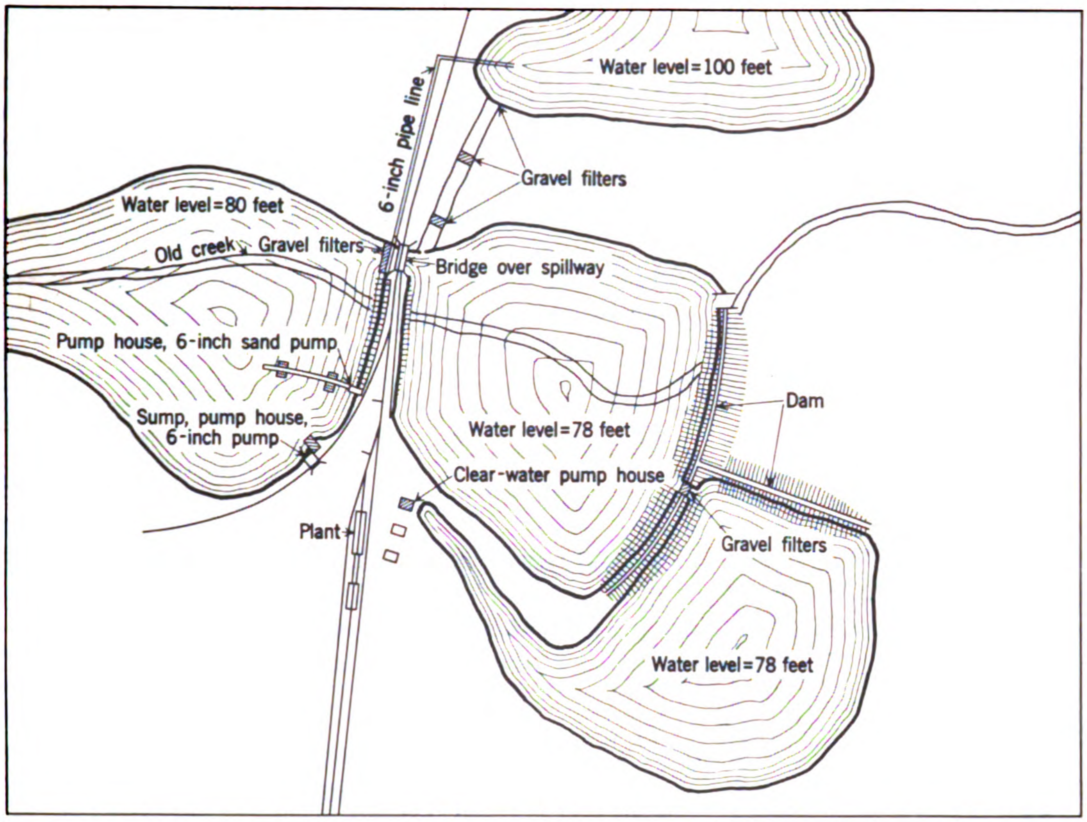

Figure 6.—Sketch showing settling basins.

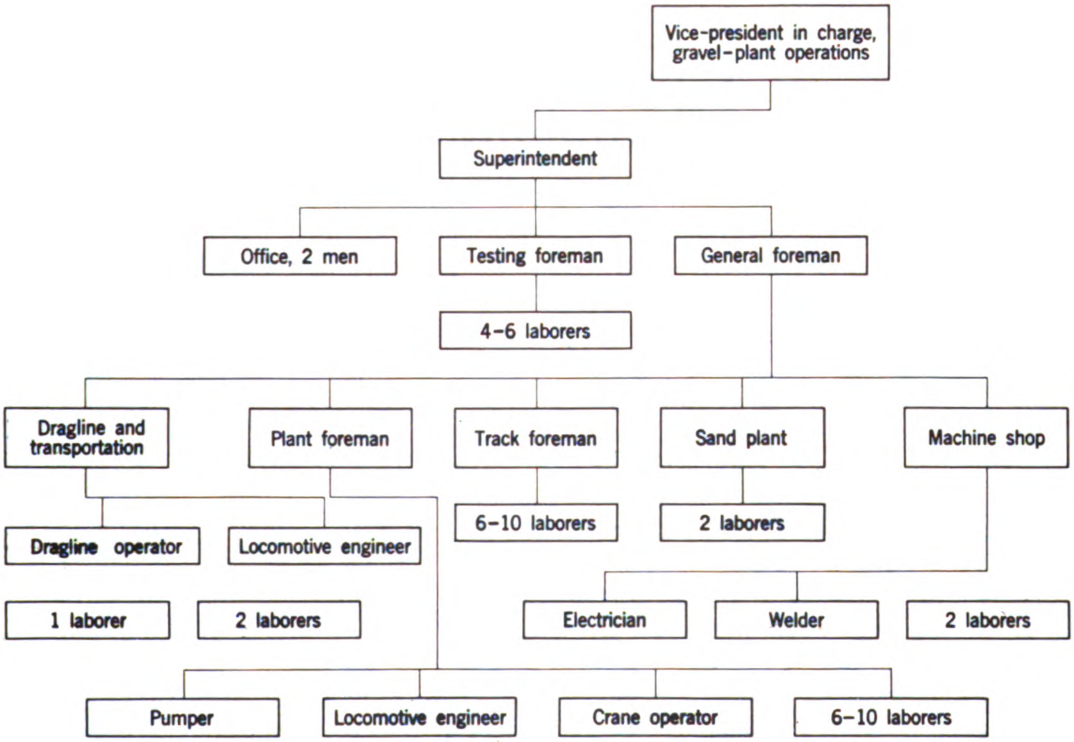

Figure 7.—Organization chart.

PERCENTAGE OF VARIOUS SIZES PRODUCED

Due to the fact that the material changes as excavation advances it is impossible to state accurately the percentage of each class of material produced. However, a rough approximation would be as follows:

	Percent
Ratio of overburden to total material handled.............	50
Ratio of material sold to material handled:	
As gravel..	30
As sand..	20
As pit run...	4
As remix...	6
As ballast...	26
Waste (fines, pea gravel, etc.)..........................	14

ORGANIZATION

The administrative organization is shown in figure 7. The wage scale prior to the adoption of the code was as follows:

	No.	Rate per hour
Drag-line operator (3-yard Monighan)........	2	$0.75
Drag-line operator (gas machine)............	1	.60
Locomotive-crane operator...................	1	.60
Locomotive engineer.........................	4	.50
Welder......................................	1	.50
Electrician.................................	1	.50
Mechanics...................................	2	.50
Topmen (plant subforemen)...................	3	.45
Pumper......................................	3	.50
Track labor.................................	-	.30
Miscellaneous labor.........................	-	.30

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SUMMARY OF COSTS

Period: August 1, 1934 to August 1, 1935

Operating costs per ton of sand and gravel mined

	Labor	Supervision	Power	Fuel	Supplies	Total
Stripping:						
Casting..................	$0.02	$0.003	.....	$0.002	$0.009	$0.034
Loading..................	.003	....	.....	.001	.001	.005
Transportation..........	.005	....	.....	.006	.005	.016
Mining:						
Loading..................	.035	.012	.....	.005	.016	.063
Transportation..........	.069	.010	.....	.049	.029	.157
Plant:						
Washing and screening...	.091	.020	$0.039	......	.040	.190
Storage......................	.024	....	.....	.007	.001	.032
Miscellaneous................	......	....	.011	......	.....	.011
Field-office expense:						
Testing..................	......	....	.....	......	.....	.042
Royalty..................	......	....	.....	......	.....	.050
Commissions..............	......	....	.....	......	.....	.025
Total..............	.247	.045	.050	.070	.101	.630

SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

Period: August 1, 1934 to August 1, 1935
(Man-hour per ton of sand and gravel)

	Stripping	Mining	Plant	Other	Total
A. Labor:					
Loading..................	$0.010	$0.015	.....	.....	$0.025
Transportation...........	......	......	.....	$0.164	.164
Plant.....................	......	......	$0.164	.....	.164
Miscellaneous............	......	......	.....	.113	.113
Supervision..............	.013	.012	.035	.015	.075
Total labor.........	.023	.027	.199	.292	.541

Average tons per man per shift.....18.5
Labor, percent of total cost.......46.5

(Kilowatt-hours per ton)

	Plant	Other	Total
Power and supplies:			
Pumping (sump to plant)........................	1.560	......	1.560
Crushing..	.112	......	.112
Screening and washing...........................	1.120	......	1.120
Shops...	.....	0.087	.087
Lighting..	.....	.020	.020
Mud pump..	.....	.480	.480
Total...	2.792	.587	3.379

Power, percent of total cost.....8.0
Fuel and supplies (fuel oil, gasoline, coal, lubricating oils, etc.)$0.07 per ton
Supplies and power, percent of total cost.....19.0

SAFETY ORGANIZATION

Safety organization and training at all plants operated by the company are handled by a safety supervisor who devotes his entire time to this work. The cost of this service is borne partly by an insurance company.

In addition to periodic inspections by the insurance company, the safety officer makes continual "follow-up" inspections to see that recommendations have been followed. Safety meetings are held at least once a month during working hours, and employees are required to be present. A safety committee of three employees is appointed at each meeting, whose duty is to bring any hazards to the attention of the next safety meeting. Men are also given thorough instruction in first-aid methods at frequent intervals. Placards and safety-first posters are placed conspicuously about the plant to remind employees constantly of dangers. First-aid kits are put at convenient points in plant and office to be available in case of accident.

The company also requires a complete physical examination of new employees and all employees are examined periodically by company physicians.